

Packard (A.S.) Jr.

ON THE
TRANSFORMATIONS
OF THE
COMMON HOUSE FLY,
WITH NOTES ON ALLIED FORMS.

BY
A. S. PACKARD, JR., M.D.



From Proceedings of the Boston Society of Natural History.
Vol. xvi, February, 1874.

ON THE
TRANSFORMATIONS
OF THE
COMMON HOUSE FLY,
WITH NOTES ON ALLIED FORMS.

BY
A. S. PACKARD, JR., M.D.

From Proceedings of the Boston Society of Natural History.
Vol. xvi, February, 1874.

ON THE TRANSFORMATIONS OF THE COMMON HOUSE FLY, WITH
NOTES ON ALLIED FORMS. BY A. S. PACKARD, JR., M.D.

It is not a little strange that the history and transformations of the common House Fly are so little known. There is a vague idea that it breeds in the manure of stables, but no one in this country has investigated its habits, and even Dr. Harris, by describing our common species under a separate name, seems to indicate that ours is not the common House Fly of Europe. In Europe, even, but little attention has been given to its habits. They are mentioned only in three works, one of which (by Bouché) was published during this century, with figures so poor and inadequate as to be actually misleading.

Having been fortunate enough to find the larvæ of this species in large numbers, and then to induce the adults to lay eggs in great abundance at our own pleasure, as it were, we make the attempt to clear up the history of the development and transformations of *Musca domestica* Linn.

Bibliography. After Linnæus had described this species as the *Musca domestica*, DeGeer¹ was the first to satisfactorily describe its transformations. He says that the larva lives in warm and humid dung, but does not say how long it lives in the egg, larva, or pupa state. He gives a good description of the larva, stating that its prothoracic stigma ends in six divisions, and adds, "Ces larves, que sont absolument sans pattes, n'ayant pas même ces mamelons charnus qu'on observe à celles de la viande [*Musca carnaria*] et de quelques autres especes, se sont des cocques de leur propre peau, mais qui n'ont rien de particulier à offrir et les mouches en sortent peu de jours apres (p. 78, Tome 6, 1776).

In 1834 Bouché² described the larva, remarking that it lives in

¹ Carl De Geer. Mémoires pour servir à l'Histoire des Insectes. Stockholm, 4° 1752-'78.

² P. Fr. Bouché. Naturgeschichte der Insekten, etc. Berlin, 1834. 12°. The third work we have alluded to is by Keller; Geschichte der gemeiner Stubenfliege, 1764 and 1796. This last we have not seen.

horse's and fowl's dung, especially when warm. He does not, however, state how long it remains in this state. After a fair description of the pupa-case, he says that it remains in this state from eight to fourteen days. His figures of the larva and pupa-case are very poor, not being recognizable; but this is the only time, so far as we are aware, that the insect has been figured in its preparatory stages.

We have been unable to find any other references, of any importance from a biological point of view, to this commonest of insects.

Embryology. During the month of August the House Fly is extremely abundant, and as we, and others, have noticed, especially so in the neighborhood of stables. On placing one fly in confinement in the shade, enclosed in a glass bottle, she laid some time between six P. M., August 12th, and eight A. M., August 13th, one hundred and twenty eggs. They were deposited irregularly in stacks, as it were, lying loose in one or two piles at the bottom of the bottle. At eight A. M., August 14th, several were found hatched out and crawling about the bottom of the bottle.

In order, however, to obtain a large number of eggs, we placed a mass of freshly dropped horse manure, still warm, at an open window in the sun. This attracted large quantities of flies for three or four weeks succeeding, which laid eggs during that period. Immediately on exposing the manure on the morning of the 12th of August, the flies appeared and laid their eggs in masses in the crevices in the manure, working their way down mostly out of sight, and depositing bunches of eggs in various convenient places. These were found hatched out at about the same hour the next day. From several such experiments made on different occasions, we may regard the embryo as requiring twenty-four hours for perfection. In confinement it requires from five to ten hours more, and those larvæ hatched in confinement are smaller than those reared from eggs deposited in warm manure. It is evident that heat and moisture are required for the normal development of the larva, as usual in all insects. Thus the egg state lasts for twenty-four hours, about the time of that of *Musca vomitoria*, according to Weismann,¹ who states that it lasts from seventeen to twenty-six hours.

The egg is elongate oval cylindrical, a little smaller, more pointed at the anterior end than the posterior. It is .04-.05 inch long, and

¹ Die Entwicklung der Dipteren im Ei, nach Beobachtungen an *Chironomus*, *Musca vomitoria* und *Pulex canis*. Zeitschrift für Wissenschaftliche Zoologie XIII., p. 107-204. 1864.

about .01 inch in diameter. The chorion is thin and structureless, but covered by an outer shell, which renders the egg quite opaque, so as to prevent one from making out the earlier embryonic changes. It is evidently secreted and laid upon the chorion just before the egg is laid. Its surface is pitted with elongated hexagonal depressions, which cross the egg transversely. Compared with the eggs of *Calliphora vomitoria*, the Meat Fly, they are rather smaller, those of the latter being .06 inch in length, and thicker in proportion, while the hexagons are in the Meat Fly larger and longer. The eggs of both flies are dull chalky white.

The micropyle is round, and easily perceived on twisting the egg under the compressor.

The yolk granules are exceedingly fine, as in *C. vomitoria*, so that the yolk is quite dense.

Owing to the density of the *exochorion*, as we may term the outer shell, it was impossible to observe the earliest embryonic changes, the formation of the blastoderm, and the primitive band. From one specimen hardened in alcohol, we succeeded in tearing off the exochorion by aid of the compressor and needles, an operation which we could not succeed in doing on recent eggs, as they invariably broke. This stage apparently agrees with that of *Calliphora vomitoria*, figured by Weismann on Taf. v., figs. 65, 66.

A more advanced stage, as seen through the exochorion, is represented by Weismann's figures 71 and 72.

At a more advanced stage (Pl. 3, Fig. 1) the embryo is nearly fully formed. The segments and locomotive spines crossing the under side of each segment are formed. The head is indicated; the two tubercles probably indicating the 1st maxillæ. The head is much larger compared to the size of the prothorax, than subsequently, and the dark Y-shaped twin spots indicate the formation of the œsophageal frame work. The anal spiracles are formed, but the spiracles are still somewhat rudimentary, though the tracheæ leading from them appear to be fully formed.

Just before the embryo hatches, the body becomes more transparent, and, as seen in Fig. 2, the main tracheæ can be traced through their whole length, with their lateral and cephalic branches. The rows of locomotive spines are very distinct. They can be easily seen in the egg in its natural state, but the figure represents the living egg with the exochorion removed, this covering having already split along the under side, just as we have seen it in *C. vomitoria*.

We feel warranted then in stating that the embryological development of *Musca domestica* is in all its stages almost identical with that of *Calliphora vomitoria*, so elaborately worked out and copiously illustrated by Weismann, in his famous work.

When the embryo is about to slip out of its egg-membranes, including the amnion, which we have observed to be as usual in the insects, it is quite active in its motions, the body moving to and fro within the shell. Undoubtedly this motion, accompanied by a twisting motion of the body, ruptures the exchorion.

We did not witness the process of hatching of the House Fly, but have no doubt it is like that of the Meat Fly (*C. vomitoria*). A larva of the latter hatched under our eyes. The egg-shell split longitudinally, and in one or two seconds it pushed its way out through the anterior end, and in a second or two more extricated itself from the shell. The shell scarcely changed its form, and the larva left the amnion within.

The larva. First stage. (Pl. 3, Fig. 3, 3*b*.) In order to bring out more clearly the characters of this stage, we shall compare it with the freshly hatched larva of the Meat Fly (*C. vomitoria*), which we studied at the same time in order to test our work on the House Fly.

The larva as soon as hatched, on being compared with that of the Meat Fly of corresponding age, differs from the latter in being slenderer, with the head in front rounder and narrower, while the posterior end of the body is rounder and narrower. The sutures in *M. domestica* are much less plainly marked, especially the three anterior ones. There are but seven rows of locomotive spines, where in *C. vomitoria* there are twelve, one for each segment (Weismann does not figure the last and minute row). Moreover, the spinules are less numerous than in *C. vomitoria*. These rows of spinules appear more clearly than in the fully grown larvæ in both genera. These differences we would regard as good generic characters, and these are, with the other characters given below, the only differential characters by which to distinguish the larvæ.

The head is much less free from the succeeding, or prothoracic, segment than in *C. vomitoria*, the suture behind being less distinct. The end of the body below the stigmata does not project so conspicuously as in *C. vomitoria*.

There are also good generic characters in the tracheæ. In *M. domestica* the two main tracheæ are more sinuate, and do not taper so rapidly anteriorly, while the distance from the posterior commissure

to the stigma is greater, and the dark terminal portion longer, than in *C. vomitoria*. The secondary branches are rather shorter than in *C. vomitoria*, and the two inferior medio-posterior tracheal twigs (Fig. 3 b) arise behind the posterior commissure. The tracheal twigs of the head are distributed much alike in both genera.

The length of the freshly hatched larva of *M. domestica* is .07 inch. It remains in this stage about twenty-four hours.

The second stage. (Fig. 4.) This stage is signalized by the addition of the prothoracic stigmata. This change must necessarily, though we did not perceive it, be accompanied by a moult of the first larva skin, as in *Calliphora vomitoria*, according to Leuckart¹ and Weismann (*l. c.*).

The length of the larva at this stage varies from .15-.17 inch in length. It is considerably slenderer than in the first stage. We are inclined to think that this stage lasts from about twenty-four to thirty-six hours. One of these larvæ grew .05 inch in twenty-four hours.

The third stage. As this last stage does not differ from the preceding one in any important respects except size, the following description will apply to both.

The larva of *M. domestica* differs from *C. vomitoria* in being proportionally longer and slenderer, more regularly conical, the body gradually increasing in width to the end, which is square. The proleg is small and inconspicuous as compared with that of the other genus, and cannot be seen from above when the larva is in motion. In *Calliphora* the body narrows towards the end, the stigmal hollow is very well marked, with eight large subacute conical tubercles on the elevated edge of the round area, which in life is stuck outwards and upwards, presenting a cup-like hollow, at the bottom of which the stigmata are situated. They are large and tun-shaped, deep testaceous in color, with fine longitudinal whitish stripes; while in *Musca domestica* they are black, external, being situated in a very slight depression, and are very conspicuous.

The anal spiracles in *M. domestica* (Fig. 5; 5 a, still more enlarged spiracle of a younger larva than 5) are rounded, forming about three-fourths of a circle, with the opposing sides square, and a broad dark chitinous ridge, which becomes wider and darker with age. The openings are two, very unequal, the longer one apparently formed by the union of what were probably originally two openings. These

¹ Die Larven Zustände der Musciden. Archiv für Naturgeschichte, 1861, p. 60.

openings are very sinuous, the fissure guarded by dense projecting cones. This sinuate course of the spiracles is the most prominent differential character of the genus *Musca*. Fig. 6 shows their disposition in *Calliphora vomitoria*, and Fig. 7 their arrangement in *Sarcophaga carnaria*, being slenderer and situated farther apart in the latter genus.

The spiracle on the prothoracic segment (Fig. 4 *c*) is divided into six lobules, rarely into eight. Fig. 4 *d* shows the end of one of these lobules, with a corrugated rim, and a central slight fissure for the admission of air.

The head (Fig. 4 *a*) is conical, about half as long as the prothoracic segment in the larva of the second stage, but much smaller proportionally in the fully grown maggot. The antennæ are minute, conical, two-jointed, the terminal joint minute, acutely pointed. Below are two fleshy tubercles, probably representing the maxillæ, and a single one, representing possibly the labrum, or upper lip. The black horny mandibles are of the usual form of the family.

The body of the maggot is much more transparent than in *Calliphora* or *Sarcophaga*. The region next the sutures, between the segments, is scarcely thickened, while it is conspicuously so in *Calliphora*, and the tegument is smooth and shining, while in *Calliphora* it is opaque and finely shagreened.

Length when fully grown, .25-.40 inch (while *C. vomitoria* measures .55-.60 inch). It probably remains in this state about three or four days. The entire life of the larva is, then, from five to seven days.

We are inclined to think that the larvæ, if hard pressed for food, devour each other, as of four larvæ put in a bottle, only two were found the day after. In the manure they eat up the decaying matter, leaving the bits of hay and straw.

Among the literally thousands of larvæ which have passed under our eyes, we have not as yet been able to detect an individual in which the body had decidedly contracted and changed its form preparatory to the formation of the puparium, and are inclined to believe this to be a comparatively sudden act.

For convenience in comparison, and to make this essay more complete, we give a brief description of the larva of *Sarcophaga carnaria*, the maggot of the common Flesh Fly, which has been known to be an inhabitant of this country for about a century, as DeGeer mentions it in 1776, in his "Mémoires," as having been received from

Pennsylvania. It is closely similar to *Calliphora vomitoria*, but a little longer. There are eleven divisions or lobules to the prothoracic stigmata, where in *Calliphora vomitoria* there are nine. The locomotive spines are more acutely pointed. The anal spiracles are of the same relative size as in *Calliphora*, but the openings are much longer and narrower, and consequently farther apart, and the circular orifice in the peritreme is wanting; in both genera the peritreme is round, while in *Musca* it is somewhat hemispherical. The fleshy projections around the spiracular depression, and the two fleshy prop-legs are the same in the two genera, *Sarcophaga* and *Calliphora*, while the head and its appendages present no differences. The only character by which to distinguish the larvæ of the two genera is in the form of the stigmata. The mode of life, and of taking food, is identical in the two; they differ but slightly in size, and here we have in the preparatory state of two allied genera, no specific characters developed, the differential ones are generic in their nature. And yet the imagines are very different, with a number of specific characters separating them.

The puparium (Fig. 8, ventral; 8 a, dorsal view, enlarged) is regularly cylindrical, at the fifth segment from the head beginning to taper regularly towards the head, the anterior end being distinctly pointed, the rudiments of the head and prothorax being small. Posteriorly the body is much rounded, full and obtuse, with no spiracular depression nor spines surrounding it, but the spiracles are situated conspicuously like little buttons on the end. On the dorsal side of the body is a single row of coarse granulations along the suture, becoming beneath double, with fine lines crossing and connected with the granulations, the distance between the rows widening posteriorly. Numerous granulations, rather finer than those anterior, surround the rudiments of the prop-legs. A raised sharp prominent lateral ridge extends on each side from the mesothoracic segment on to the first abdominal. Prothoracic spiracles very minute, with usually six lobules, and not extending beyond the mouth parts. The prop-legs are represented by two oval flattened parallel contiguous tubercles, with a rather remote and obscure area on each side. The anal spiracles form black, round, flattened, button-like tubercles, the terminal segment being smooth and shiny, and regularly convex.

Length, .20-.27 inch.

So remarkably similar is the puparium of *Musca domestica* to that

of *Stomoxys calcitrans*¹ (Fig. 10, dorsal; and 10 a, ventral view of an immature puparium, in which the pupa is very rudimentary, the abdomen being continuous with the thorax) that it is difficult to give any characters by which to separate them. The two most important ones are the following; the anal spiracles of *Musca domestica* (Fig. 9) are larger, much closer together, square on the opposing faces, and depressed in the middle, while those of *Stomoxys calcitrans* are remote, round, and flat topped. (10 c.) The lower side of the end of *Stomoxys* is darker and much more rugose, owing to transverse ridges, than in *Musca*, where it is comparatively smooth. Fig. 10 b gives an idea of these ridges and transversely oval enclosures. The ridges lying between the spiracles and the region of the prolegs are wanting in *Musca domestica*.

In both genera the prothoracic spiracles of the pupa connect with similar projecting, slightly twisted, long acute points which are situated on each side on the hinder edge of the metathoracic segment of the puparium. These stigmata are not represented in either of the drawings of the puparia we here present. The divisions of the prothoracic stigmata in the puparium of *Stomoxys* are five in number. The puparia of this species occurred more abundantly with us than those of the Domestic Fly, and were at first mistaken for them. The puparium of *M. domestica* may at once be distinguished from *Calliphora* and *Sarcophaga* by the obtusely pointed (compared with those of *C. vomitoria* and *S. carnaria*) end, and the full rounded hind end, with the spiracles externally like buttons; also by its smaller size, and by the double row of large granulations, while in *Calliphora* and *Sarcophaga* there are twelve or more.

In *Musca*, as well as in *Stomoxys*, when the pupa is formed, the hard frame work of the jaws of the larva rest next to the skin of the puparium, and always on the ventral side, and apparently in connection with the old larva skin. When the fly pushes its way out of the pupa case, the anterior end of the latter splits off just behind the suture between the metathoracic and first abdominal segment. And often when the front end of the puparium is forced off, the ventral half, with most of the rudiments of the mouth-parts, remains attached to the case.

A parasite found in the puparium of *Musca domestica* will be described at the end of this essay.

¹ As has been noticed by Bouché (*l. c.*, p. 56) as regards the larval state.

The puparium of *Calliphora vomitoria* is cylindrical, slender, flask-shaped, being thickest on the anterior third of the body, thence gradually narrowing to the posterior end and suddenly contracting, leaving a well marked neck, which is much darker colored than the rest of the body, which is of the usual dark red color. The spiracles are quite prominent, extending as far as the extreme tip of the head; they are of much the same form as in the larva, and with from twelve to thirteen deeply marked divisions. (In one larva there are nine lobules.)

Two broad bands and a narrow linear accessory line of minute granulations cross each segment, and become curved a little anteriorly along the dorsal line. The constricted end of the case is provided with twelve prominent rugose granulated spines, with longitudinal ridges on the neck terminating between the spines; and along the ventral side of the neck is a ridge, less sharp and prominent than in *Sarcophaga*, and with larger granulations. The rudiments of the prop-legs consist of two lateral conical projections and a median furrow. The projections are a little farther apart, and more slender than in *Sarcophaga*, but the differences are very slight. The dorsal ridge ending between the two uppermost circum-anal projections is obscurely marked, while in *Sarcophaga* it is distinct and sharp.

The divisions of the stigmata are very plainly and deeply cut, while in *Sarcophaga carnaria* there are no indications of the incisions,

the edge being rugose, but not crenulated. This is the most important distinguishing mark in the puparia of the two genera. Length .30-.35 inch.



Puparium of *Sarcophaga carnaria*.

The puparium of *Sarcophaga carnaria* (described from specimens received from Rev. Mr. S. Lockwood) is twice as bulky as that of *Calliphora vomitoria*. It is cylindrical, not tapering so gradually posteriorly as in *C. vomitoria*, and not contracted at the end into so long a neck. The twelve blunt spines surrounding the spiracular region are much smaller, less conspicuous, and do not project, except the two lower ones, beyond the end of the puparium. The ridges ending between these spines are much higher and sharper than in *C. vomitoria*. The dorsal

ridge on this neck is much sharper and more pronounced than in *C. vomitoria*, and the impressed lines on the sides extend forwards to the suture between the penultimate and terminal segments of the body, the lines curving outwards anteriorly. There is a well-marked pointed short ventral ridge behind the rudiments of the ventral prolegs. This ridge is obscurely marked in the puparium of *C. vomitoria*, except that the prothoracic spiracles are much less prominent, not projecting beyond the head, their extremities being just parallel with the end of the rudimentary mouth-parts. The edge of the spiracle is rugose, but I have been unable to distinguish any signs of lobules. The lines of pointed granulations are arranged much as in *C. vomitoria*. Length .50 inch.

The pupa. (Fig. 11.) The pupa of *M. domestica* may at once be known by its broad spatulate labium or tongue, and the curved, almost elbowed maxillary palpi. The antennæ (Fig. 11 *d*) are distinctly three-jointed, with a large, stout bristle. Fig. 11 *a* shows one of the legs with the trochanter hanging to it; Fig. 11 *b* the wing, surrounded by its membrane; and Fig. 11 *c* the optic lobes, and their connection with the unorganized cornea and facets of the eyes; the outer surface of the eye being covered with fat cells, destined to form pigment cells, which finally turn reddish.

The figures 12, 12 *a*, 12 *b*, show the corresponding stage in the pupa of *Stomoxys calcitrans*; here can be seen the generic characters which separate this fly from the House Fly, *i.e.*, the elongated beak, the smaller, narrower, more pointed head. The mouth-parts with the long maxillæ (*mx*) and mandibles (*m*), and the straight maxillary palpi, are shown in the enlarged view (Fig. 12 *c*).

On removing the puparium we were able to obtain a portion of the semipupa of *Stomoxys* (Figs. 13, 13 *a*) *i.e.*, the thorax, the head adhering to the pupa-case, and only the basal segment of the abdomen being brought to view; enough, however, to show that they were nearly of the form of those of the larvæ. This stage compares almost exactly with that of *Calliphora vomitoria*, as figured by Weismann, Tab. XII., Figs. 38, 39, 40. This stage is intermediate between the larval and pupal, and may be properly termed the semipupa.¹

¹ Professor von Siebold, in his "Beiträge zur Parthenogenese der Arthropoden," 1871, p. 35, calls this stage *pseudonymph*. As this state is necessarily universal in all metabolous insects, it seems incorrect to regard it as a false or unusual state, and we therefore may be pardoned for retaining the name first proposed by us in 1866. (Proc. Bost. Soc. N. H., x, 279.)

Similar intermediate stages have been shown by us to exist in the Hymenoptera, Lepidoptera, and Coleoptera, and in other Diptera. It shows that the distinction between the larval and pupal stages are as truly artificial as in the ametabolous insects.

Fig. 13 is a dorsal view of the three thoracic segments, with the anterior leg attached, and the wings. The segments are very indistinctly marked. The prothoracic stigmata are very near together though so widely separated in the fully formed pupa. Fig. 13 *a* is a ventral view of the same parts, the parts somewhat distorted; it also represents the wings, and the two hinder pairs of legs, and 13 *b* the fore leg; the joints of the legs are clearly indicated.

The next stage in the pupa of *Stomoxys* was much farther advanced, the thorax being formed much as in the mature pupa, as also the abdomen. The body is still much longer than in Fig. 12, the head narrower and freer from the body, and the vertex more elongated. The mouth-parts do not reach much beyond the anterior third of the body, while the wings reach only to the middle of the body (the head excluded), and the hindermost legs only reach a little beyond the middle of the body (the head excluded), and a little way beyond the end of the wings. Viewed dorsally, the thorax is much shorter than in the stage represented by Fig. 12, and the scutellum is short and small, being still quite rudimentary. The form of the eyes can just be distinguished, and the antennae can with difficulty be perceived.

Fig. 12 represents the succeeding stage of the pupa of *Stomoxys*, which may be said to fairly represent the typical pupa condition of the cycloraphous diptera. At this time the body is pure white, the eyes are unchanged in color, and under low powers there are no traces of hairs to be seen. In this and the following stages the proportion in the length of the wings and legs, and mouth-parts, remains nearly the same. The wings reach to the middle of the abdomen, while the hind legs just pass beyond the tip end of the abdomen. The mouth-parts reach to the second abdominal segment. The eyes and antennae are clearly indicated (the latter not shown in the drawing). The stages beyond differ but slightly, and form exceedingly gradual steps towards the imago. They differ chiefly in the degree of maturity of the tegument and hairs. In one example, in which the sutures are much more distinct than in Fig. 12, the body is slightly dusky, but the eyes are beginning to turn rosy around a portion of the edges. The hairs are also apparent. In a more advanced stage the eyes are a deep scarlet, the hairs are brown, the wings and legs are dusky.

The prothoracic spiracle, with its black, corneous tip, is much the same in all the specimens.

Having had more alcoholic specimens of the pupa of *Stomoxys* than of *Musca*, we have not been able to trace these stages in the latter genus, but doubt not that similar ones occur in all the *Muscidae*.

The imago. On leaving its puparium the fly runs around, with its wings soft, small and baggy, much as in the pupa. They reach a little beyond the middle of the abdomen, and are still pressed to the side of the body. It is pale, as in the puparium, and the colors are not set. The membranous portion of the front is constantly distending as the fly walks rapidly about. When this part is contracted it forms a dull livid area, soft and fleshy, free from hairs. This portion suddenly distends into a bladder-like expansion, trapezoidal in outline, equal in bulk to the rest of the head, and pushing the antennae down beneath out of sight. This thin membrane is evidently distended with air, and its connection with the tracheae, and the mechanism of its movements, would form a most interesting subject of inquiry. This part has been described by Mr. T. B. Lowne, in his work on the "Anatomy of the Blow Fly," and he is evidently correct in regarding it as an organ for pushing away the end of the puparium when the pupa slips out of its case.

The common House Fly, though so abundant, is difficult to distinguish from the allied species. The generic characters may be found in the mouth-parts, already described by authors. In the venation of the wing it differs decidedly from *Sarcophaga*, in the end of the median vein being bent nearly at right angles, and in being regularly but slightly incurved, while in *Sarcophaga*, it is bent at a much lower angle, being much more oblique. From the genus *Lucilia*, which it much nearer approaches structurally, it differs in this vein being still bent at a greater angle, and in having the bent extremity more curved. In *Stomoxys* this vein is but slightly bent, thus widely differing, besides in its remarkably long horny beak, from *Musca*, with its short fleshy bilobed tongue.

The body of *M. domestica* is black; the head has a longitudinal reddish oval smooth area on the vertex, with the orbits and adjacent region golden (or silvery in some lights); the hairs are black, and the antennae and plume are black. The thorax is black, tinged with golden gray on the sides, with three dorsal gray longitudinal bands, the middle one most distinct, the two lateral ones partially interrupted in the middle and continued on to the scutellum; there is a

broad lateral golden gray band interrupted by the sutures. The base of the first abdominal segment has a yellowish band, interrupted in the middle. On the middle of the end of the two succeeding segments is a triangular mesial golden spot, with an oblique irregular band on each side, and farther down the sides golden; terminal segment golden. Base of wings, scales and halteres yellowish-white. Legs black.

The male differs from the female in the front between the eyes being about one-third as wide as in the latter, while she is rather the smaller. Length .22-.32 inch.

The species agrees in most particulars with Harris' description of *Musca harpyia* in his "Correspondence," and we are inclined to think that individuals of this species formed the subject of his description. After comparing it with about a dozen specimens of *Musca domestica* received from Switzerland (through the kindness of Mr. S. H. Scudder), we cannot find that it differs in any respect from them. The golden color that Harris calls silvery, the reddish oval spot on the vertex, the black hairs on the thorax, are the same in specimens from America and Switzerland. Both also agree in the venation and form of the head and front.

SUMMARY OF ITS HISTORY.

The eggs are laid about one hundred and twenty in number, and in twenty-four hours the larvæ are hatched.

There are three stages of the larval state, and consequently two moults.

The first stage lasts about one day (twenty-four hours).

The second stage lasts about one day.

The third stage lasts three or four days.

The entire larval state averages from five to seven days.

The pupal state lasts from five to seven days.

The period from the time of hatching to the exclusion of the imago lasts from ten to fourteen days in the month of August.

Those larvæ which were reared in too dry manure were nearly one-half smaller than those taken from the manure heap. For several days the larvæ living in this dry manure did not grow sensibly. Too direct warmth, but more especially the want of moisture, and

consequently of available semi-liquid food seemed to cause them to become dwarfed.

Parasite of Musca domestica. While no insect parasite has yet been hitherto found, so far as we are aware, in the House Fly, it is, in fact, preyed upon by a Coleopterous larva. In one puparium we discovered a large hole which had been eaten through the crust in the anterior third of the body. Another puparium, on being opened, was found to contain the pupa of a beetle, of which Fig. 14 *a* is a dorsal, and Fig. 14 *a* a ventral view. It is long and slender, with the abdomen unusually attenuate. Seen dorsally the prothorax is very broad, twice as broad and nearly concealing the head. The wings were free, not laid on the body; the anterior pair short and broad, the hinder pair much longer and narrower. The segments of the abdomen are convex, each side giving rise to a hair. The abdomen gradually narrows, the terminal segment being lunate. From under each side of it extends a remarkably long and large appendage ending in a long bristle.

Seen ventrally the filiform ten-jointed antennæ are widely inserted and diverge, extending along the front edge of the anterior wings, reaching a little beyond their middle. The hind tarsi extend to the middle of the abdomen.

The two most interesting characters are the slenderness of the body, and the large long terminal abdominal appendages, which are rarely met with in Coleopterous pupæ. From the sum of its characters here given we should feel inclined at present to locate this remarkable pupa in the family of Dermestidæ, with whose characters it agrees better than any other group of which we know the transformations. Of the vegetable parasites of the House Fly, of which there are several, we cannot now speak.

EXPLANATION OF PLATE III.

Fig. 1. Embryo of *Musca domestica* in an egg which has not been laid over twenty hours. Exochorion removed.

Fig. 2. Embryo of *Musca domestica* still farther advanced, the egg having been laid about twenty-four hours; the exochorion artificially removed, the embryo on the point of hatching.

Fig. 3. Larva of *Musca domestica* just hatched; showing the distribution of the two main tracheæ and the anterior and posterior commissures, (*a, a*) dorsal view. *3b*, the same, showing the mode of origin of the pair of lower postero-median tracheal branches, seen from beneath.

Fig. 4. Larva of *Musca domestica* in the second stage; *sp*, prothoracic spiracle; *4a*, head; *at*, antennæ; *mx*, maxillæ; *md*, mandibles; *4b*, spiracles of *Musca domes-*

area, divided into seven lobules. 10, full grown larva of *Musca domestica*, showing the size of head relative to the prothoracic segment, with its spiracle. 4d, end of lobules of the spiracles, much enlarged.

Fig. 5. Two anal spiracles of *Musca domestica*. 5a, spiracle (much enlarged) of a younger larva than the subject of fig. 5, with a narrower peritreme, and the subcentral depression nearer the centre of the spiracle.

Fig. 6. Spiracles of *Calliphora vomitoria*.

Fig. 7. Spiracles of *Sarcophaga carnaria*.

Fig. 8. Ventral view of puparium of *Musca domestica*. 8a, dorsal view of same puparium; 8b, prothoracic spiracles; 8c, end of body.

Fig. 9. Spiracles of puparium of *Musca domestica*.

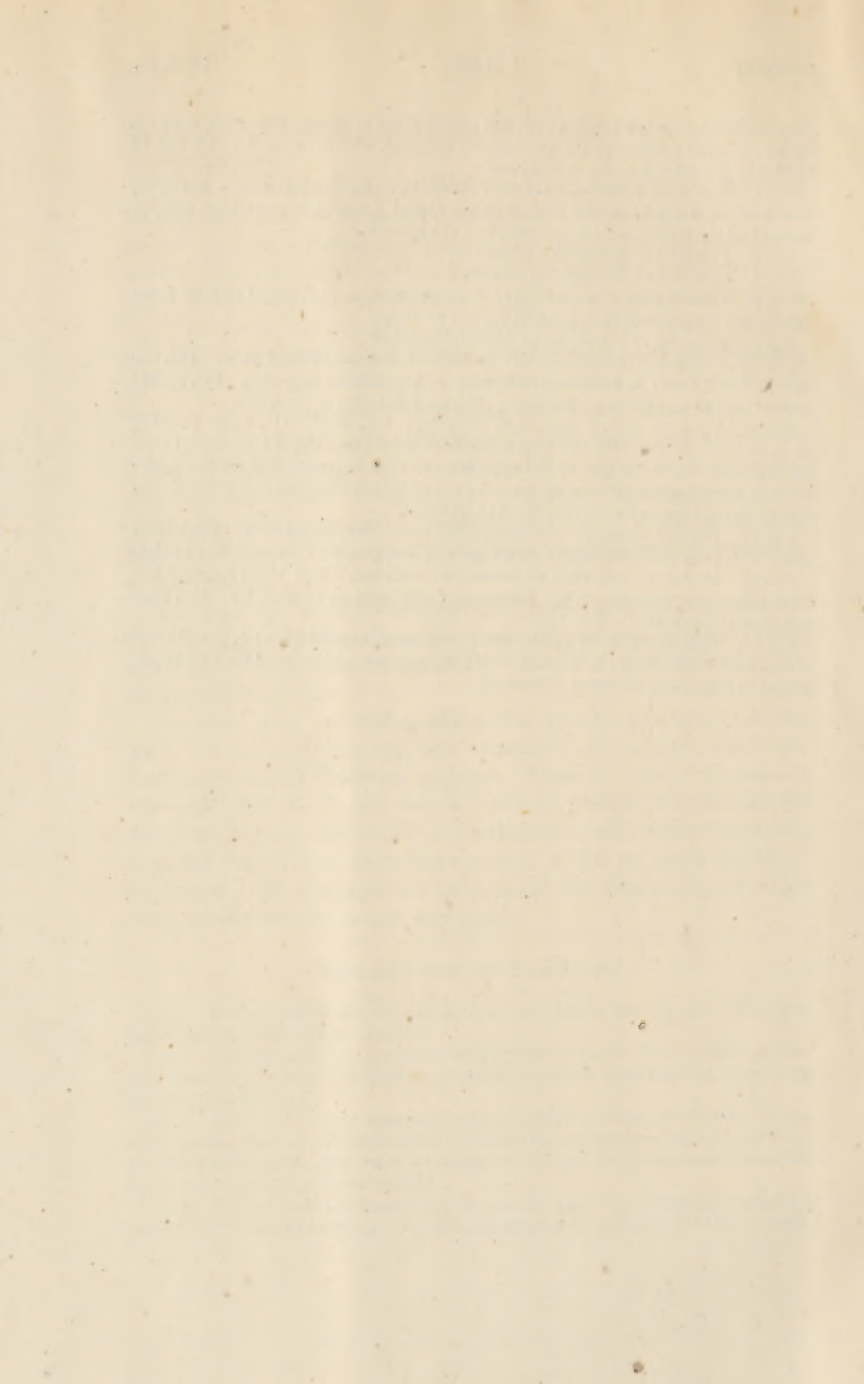
Fig. 10. Puparium (immature) of *Stomoxys calcitrans*, dorsal view. 10a, the same, ventral view; b, head-end enlarged; c, prothoracic spiracles. 10d, profile view of end of puparium of the same. 10e, anal spiracles of the same.

Fig. 11. Pupa of *Musca domestica*. 11a, leg. 11b, wing. 11c, optic ganglia. 11c, optic lobes, divided into two well marked divisions; oeg, upper oesophageal ganglion, resting above the base of the optic lobes; e, eye in profile, and on the opposite side the unorganized mass of fat cells, out of which the optic fibres and chambers of the eye are to be developed. 11d, antenna.

Fig. 12. Pupa of *Stomoxys calcitrans*, front view. 12a, dorsal view. 12b, lateral view. 12c, head much enlarged; m, mandibles; mx, maxilla; mp, maxillary palpi.

Fig. 13. Thorax of semipupa of *Stomoxys calcitrans*, dorsal view, showing the three thoracic segments. st, the prothoracic stigmata; w, wing; l, leg. 13a, ventral view of the same; b, fore leg.

Fig. 14. Pupa probably of one of the Dermestidae, ventral view; b, dorsal view of the end of the body; c, ventral view; d, antenna. 14a, dorsal view of pupa. Found in Puparium of *Musca domestica*.





H. S. PACKARD DEL.

C. A. HOLLAND SCUL.

PACKARD, TRANSFORMATIONS OF THE HOUSE FLY



